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**K $\alpha$  Emission in Equilibrium and Non-Equilibrium  
Plasmas\***

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A detailed spectral model has been under development for the computer simulation of  $2p \rightarrow 1s$  K $\alpha$  X-ray emissions from highly-charged Fe ions in plasmas. These emissions occur in the spectral range from 1.84 Å to 1.94 Å. Account has been taken of the fundamental radiative emission processes associated with radiationless electron capture or dielectronic recombination, inner-shell electron collisional excitation, and inner-shell electron collisional ionization. In high-temperature plasmas, small or moderate departures from steady-state corona-model charge-state distributions may occur due to the effects of ion transport processes. However, the assumption of equilibrium (Maxwellian) electron energy distributions is usually assumed to be valid. Particular emphasis has now been directed at the identification of spectral features that can serve as diagnostics of extreme non-equilibrium or transient-ionization conditions, which can occur in both low-density and high-density plasmas as well as in electron-ion beam interactions. In the development of the general theoretical description of the emission spectra, it has been necessary to allow for an arbitrary (non-Maxwellian) electron energy distribution. In order to provide a microscopic investigation of the fundamental K $\alpha$  line-formation processes that can play a dominant role under extreme non-equilibrium conditions, the observed X-ray emission spectra from Fe ions in the Electron Beam Ion Trap (EBIT) have been simulated. For the precise interpretation of the high-resolution X-ray observations, which may involve the analysis of blended spectral features composed of many lines,

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it has been necessary to take into account the multitude of fine-structure components of the  $K\alpha$  radiative transitions in the ions from Fe XVIII to Fe XXV.

A complex situation can be encountered for densities that are higher than the validity range of the simple corona-model approximation. With increasing density, collisionally-induced transitions among the low-lying fine-structure levels can play an important role. We have developed a hierarchy of simplified statistical-population models for the distribution of the initial ions among the different low-lying fine-structure levels. The inadequacies of this simple approximation can be fundamentally remedied only by the application of a detailed (and possibly time-dependent) collisional-radiative-model description of the excitation, de-excitation, and ionization processes. It has been found that inner-shell electron excitation and ionization processes involving the complex intermediate ions from Fe XVIII to Fe XXI produce spectral features, in the wavelength range from 1.89 Å to 1.94 Å, which are particularly sensitive to density variations and transient ionization conditions. For a precise analysis of the X-ray observations produced by anisotropic (directed) electron collisional excitations, it will be necessary to taken into account the angular distribution and polarization of the emitted radiation.

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